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THE BURN-OFF OF WASTE LUBRICATING OILS IN COAST GUARD POWERPLAN--ETC(U)
AUG 76 J R SHERRARD, R A WALTER

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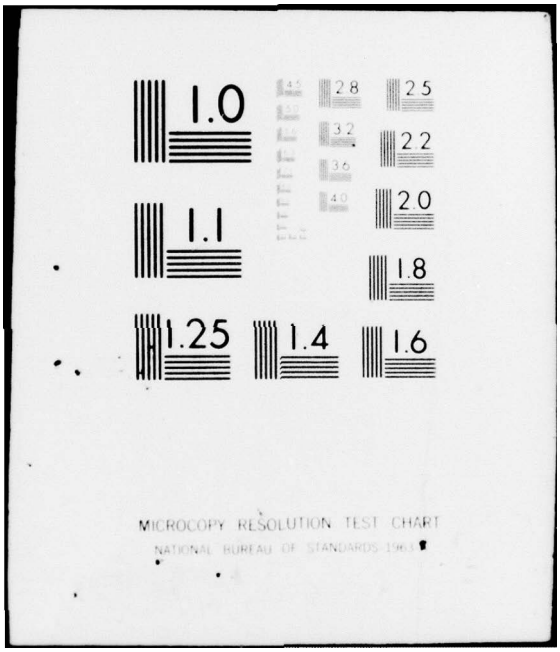
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THE BURN-OFF OF WASTE LUBRICATING OILS IN COAST GUARD POWERPLANTS

J. R. SHERRARD
R. A. WALTER

AUGUST 1976

EXECUTIVE SUMMARY

Prepared for

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
Office of Research and Development
Washington, D.C. 20590

METRIC CONVERSION FACTORS

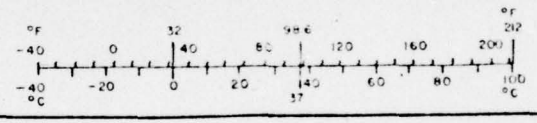
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



METRIC CONVERSION FACTORS

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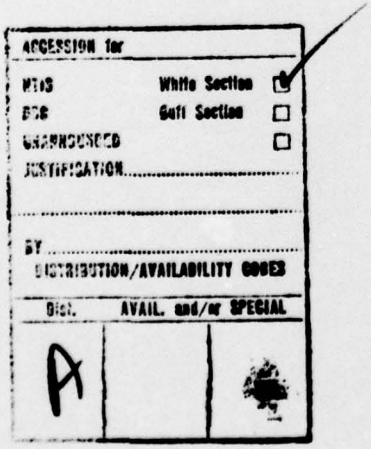

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J. R. Sherrard, R. A. Walter

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16. Abstract

This report summarizes the results of a study to investigate the feasibility of utilizing waste lubricating oils as fuel in Coast Guard powerplants. Adoption of this practice by the Coast Guard would conserve diesel fuel, as well as minimizing environmental degradation and eliminating costs associated with lube oil disposal. It was concluded that the Coast Guard can safely use this lube oil as fuel if it is properly filtered and mixed at the correct ratios with the fuel oil. Various filtering devices were tested and the correct mix ratios for diesel engines, boilers, and gas turbines were determined. It was found that with these safeguards the practice of lube oil burn-off will not adversely affect engine emissions, performance, maintenance, or wear characteristics. Final recommendations and conclusions were made to the Coast Guard for the adoption of this practice.

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EXECUTIVE SUMMARY

Introduction

The U. S. Coast Guard used 356,900 gallons of lubricating oil during the last quarter of 1975 and the first three quarters of 1976. Some of this lubricating oil is inevitably lost to the environment through burn-off, leakage, and spillage. The remainder of this lubricating oil can be recovered from dirty oil tanks and bilges and is an energy source worth approximately one dollar per gallon. In addition, the Coast Guard can pay up to 12 cents per gallon for dirty oil disposal. In 1975, the Coast Guard requested the Transportation Systems Center (TSC) to investigate a method of utilizing this presently wasted resource. This method is to mix the waste lube oil with the fuel oil and burn the mixture in the diesel engines, boilers, and turbines of the Coast Guard fleet.

Discussion

The CG and TSC determined that an investigation of this method of waste oil disposal should be in three major areas: (1) A feasibility study, (2) Methods to clean-up waste lube oils to produce a suitable product for mixing and burn-off, (3) The determination of the proper mixing ratio for diesel engines, boilers, and turbines and the effects on the powerplant performance when burning these mixtures.

In the feasibility study (Ref. 1), we investigated existing programs of lube oil burn-off in the commercial diesel trucking fleet and solicited the recommendations of diesel engine, boiler,

and gas turbine manufacturers. A literature search in these areas was completed as well as a study of the physical characteristics of lubricating and fuel oils.

The most thoroughly tested lube oil burn-off program was developed by Cummins Engine Company, Inc., for their diesel engines in the Coors Beer Company truck fleet. This program consists of filtering the drained diesel lube oil through four filters identical to spin-on diesel engine bypass filters except for a final Luber-Finer* filter. This filtered oil is mixed with fuel oil at a ratio of 3% by volume and burned in the Coors truck fleet. Since the Coors tests, Cummins Engine Company, Inc., has released a service bulletin on the use of treated 5% lube oil in No. 2 diesel fuel.

Kroger Company, Cincinnati, Ohio, has also developed a lube oil burn-off program for its fleet of trucks equipped with Detroit Diesel 8V-71 engines. Four engines are operating on a 5% filtered lube oil/fuel oil mixture. The filtering system used is a specially designed Fram unit.

International Harvester Company has also issued a service bulletin for its diesel engine users which recommends filtering the waste lube oil through a funnel with a fine mesh screen. The filtered oil is added to the truck's fuel tanks, which are then filled with diesel fuel up to a miximum of 6-1/2% lube oil/fuel oil ratio.

The following engine, boiler, and gas turbine manufacturers provided us with information: Allis-Chalmers, Babcock and Wilcox,

*Trademark of Luber-Finer Inc., Division of Rockwell International

Caterpillar Tractor Company, Colt Industries, Cooper-Bessemer Company, Cummins Engine Company, Detroit Diesel Allison (GM), General Electric Gas Turbine Products Division, International Harvester Company, and Turbo-Power Marine Systems of United Technology. Eighty-four references, patents, and contracts in this area were evaluated. We examined Mil-F-16884F diesel fuel oil requirements, Mil-L-9000G diesel lubricating oil requirements, as well as PWA-527 and GE gas turbine fuel requirements.

An evaluation of waste oil filtering devices (Ref. 2) was the second major effort of this study. Two devices were evaluated:

1. The oily-water separator (presently being installed on all cutters). Both the 5 GPM (gallon per minute) and 100 GPM units were evaluated.
2. An inexpensive filter pack manufactured by Luber-Finer Inc., and recommended by Cummins Engine Company, Inc., for this application.

Lubricating oils and bilge were obtained from Coast Guard Base Boston Support Center and First Coast Guard District cutters. This oil was analyzed before and after treatment. The results of these tests, as well as the feasibility study, were used to establish a proper mix ratio for diesels, boilers, and turbines. These oil samples were measured for water content, insolubles, soluble trace metals, and particulates. Various techniques such as prior diesel fuel oil dilution were attempted to improve system efficiency.

As the diesel engine uses 63% of the fuel in the Coast Guard fleet, a major effort was the determination of diesel engine performance, emissions, fuel economy, and ring/cylinder-liner wear when burning these mixtures of lube and fuel oil. (Refs. 2 and 3). Initial tests were performed with a mixture of 1:100 lube oil in fuel oil and a Caterpillar D333-C four-stroke cycle diesel engine. The engine was operated over the Federal Emissions Test Cycle. More comprehensive emissions and performance tests were performed using a GM6-71 two-stroke cycle diesel engine. Radioactive tracer-wear tests of the top compression piston ring were performed on an identical 6-71 engine. The 6-71 engines were marine configured and operated at engine speed and power points duplicating a propeller load. The emissions measured were carbon monoxide, carbon dioxide, oxides of nitrogen, and total hydrocarbons. For the emissions and wear tests rpm, torque, fuel consumption, and various temperatures and pressures were also measured. For the radioactive wear tests, the iron and chromium wear products in the lubricating oil were continuously monitored through 350 hours of testing with standard fuel and mixtures of lube oil in fuel oil. The mixtures of lube oil in fuel oil varied from 1:100 to 10:100 for these tests.

Conclusions

We conclude from the results of this study that:

- Mixtures of 1:100 by volume filtered lube oil in fuel oil can be burned in Coast Guard diesel engines without affecting engine emissions, performance or wear rates.

- Mixtures of 1:100 filtered lube oil in fuel oil can safely be burned in Coast Guard propulsion and hotel-service boilers.
- Lower mixtures of filtered waste lube in fuel oil (approximately 1:5000, depending on lube oil trace metal content) can safely be burned in gas turbines.
- The utilization of this waste lube oil would conserve diesel fuel, and minimize environmental degradation and disposal costs.
- The oily water separator, used in its normal operating mode, effectively filters particulate matter from waste oil. However, it further contaminates the lube oil with water and insoluble trace metals.
- A filtering system, such as the Luber-Finer tested here, is effective in removing particulates, insoluble trace metals, and, to a lesser degree, water from waste lube oils.
- No filtering system tested will remove soluble trace metals found in lube oil. These trace metals (Na., K., Pb., Va., and Ca.) produce "hot corrosion" of the blades in gas turbines.
- All diesel engine manufacturers whose recommendations were solicited, except General Motors (Detroit Diesel) endorse the burn-off of waste lubricating oils in fuel oil. All manufacturers stressed two requirements:

(1) Proper oil filtration

(2) Low mix ratio (1:100 to 5:100)

- General Motors indicated that burning even small quantities of lube oil in their two-stroke cycle engines may contribute to increased deposits and wear in the cylinders, rings, and valves. However, no increases in wear rates were indicated in our tests with a GM6-71 engine.
- Commercial diesel trucking fleets, engaged in lube oil burn-off, report no adverse effects with mixtures up to 6:100.
- The American Petroleum Institute, boiler manufacturers and industrial boiler users endorse a lube oil burn-off program in boilers.

Recommendations

From the results of these tasks, we make the following recommendations:

- The Coast Guard adopt a waste lube oil burn-off program in fleet diesel engines, boilers, and gas turbines.
- Waste lube oil must be filtered prior to burn-off to remove particulates, insolubles, and water.
- A filter system, such as the Luber-Finer tested here, be installed on larger cutters for treatment of waste lube oil (approximate cost per cutter — $500.00). Prior to treatment the used lube oil should be mixed

with clean fuel oil at ratios of 1:2 or 1:3 for ease of filtering.

- For smaller cutters and boats, similar type filters should be made available at shore facilities for treatment and subsequent burn-off.
- On cutters without turbines, the treated used lube oil should be mixed into the fuel tank(s) such that a mix ratio of 1:100 or less is maintained.
- On gas turbine equipped cutters (378' WHEC, 210'A WMEC, and Polar icebreakers) small quantities of filtered waste lube oil should be burned-off at mix ratios of 1:5000 or less. For instance, only 50 gallons of treated waste oil could be distributed among the 20 fuel tanks of the 378' WHEC with a full fuel load of 250,000 gallons. Only four gallons could be mixed into the 20,000 gallon day task. For larger quantities of lube oil (in excess of 50 gallons), the trace metal content of the oil should be determined from the routine spectrographic lube oil analysis program. This trace metal content should be used to determine a mix ratio that satisfies the United Technology, Turbo-Power Marine Systems, fuel requirement (Ref. 1, Table 12). The waste oil could then be stored in an oil tank and metered into the fuel system at this predetermined mix ratio. Alternatively, the waste lubricating oil could be burned-off at

ratio of 1:100 (200 gallons of lube oil in the 378' WHEC day tank) during periods of exclusive diesel operation.

- On cutters equipped with separate fuel tanking for ship-service boilers, for instance Wind and Wind R icebreakers, the waste oil should be burned-off exclusively in these boilers at the 1:100 mix ratio.
- A trial lube oil burn-off program should be initiated for a one year period on one ship of each of the following classes:

  WAGB (Wind or Wind R)

  WHEC 378' and 327'

  WMEC 210'A and 210'B

  This trial program would assist in establishing operation procedures and assure no long term adverse effects.
- A new entry should be added to the machinery log in the fuel and water record to keep a running total of the quantities of waste lube oil mixed into the fuel tank(s).

It should be emphasized that the 1:100 mix ratio established for diesel engines and boilers is conservative. This mix ratio could be increased up to 5:100 for short periods of engine and boiler operation without producing any measurable change in emissions, performance, wear, or maintenance. Also, a mix ratio of 1:5000 for gas turbines is conservative. Any trace metal turbine corrosion effects would be minimized because of the derated Coast Guard operation with resultant lower temperatures and the water wash maintenance procedures.

REFERENCES

1. Hobbs, J. R., R. A. Walter. Lubricating Oil Burn-Off in Coast Guard Power Plants, A Feasibility Study. Report No. CG-D-80-75, February 1975.

2. Hobbs, J. R., R. A. Walter. Waste Oil Burn-Off in Coast Guard Power Plants - Waste Oil Filtering Systems and Diesel Engine Performance. Report No. CG-D-78-76, June 1976.

3. Storment, J. O., J. R. Sherrard. Waste Oil Burn-Off in Coast Guard Power Plants - Diesel Piston Ring Wear Study by Radioactive Tracer Techniques. Report No. CG-D-84-76, July 1976.